405312

403 312

HYDROMECHANICS

CAVITATION TESTS OF ESCORT RESEARCH VESSEL
COUNTERROTATING PROPELLERS 3808 AND 3809
IN SIMULATED WAKE

bу

James G. Peck

0

STRUCTURAL MECHANICS

HYDROMECHANICS LABORATORY
TEST EVALUATION REPORT

Q

APPLIED MATHEMATICS

March 1963

Report 1731

PRNC-TH9-6484 (Rev. 3-58)

CAVITATION TESTS OF ESCORT RESEARCH VESSEL COUNTERROTATING PROPELLERS 3808 AND 3809 IN SIMULATED WAKE

bу

James G. Peck

March 1963

Report 1731 S-F013 02 04

TABLE OF CONTENTS

ARSTRACT		Page
PROCEDURE	ABSTRACT	. 1
IIST OF FIGURES Figure 1 - Drawing of Model Propeller 3808	INTRODUCTION	1
Figure 1 - Drawing of Model Propeller 3808	PROCEDURE	1
Figure 1 - Drawing of Model Propeller 3808	RESULTS	2
Figure 1 - Drawing of Model Propeller 3808		
Figure 1 - Drawing of Model Propeller 3808		
Figure 1 - Drawing of Model Propeller 3808		
Figure 2 - Drawing of Model Propeller 3809	LIST OF FIGURES	
Figure 2 - Drawing of Model Propeller 3809	Figure 1 - Drawing of Model Propeller 3808	5. *
Figure 3 - Comparison of Simulated Tunnel Wake with Escort Research Vessel Model Wake		•
Vessel Model Wake		5
Figure 5 - Inception Curves of Visible Cavitation on Model Counterrotating Propellers		6
Figure 5 - Inception Curves of Visible Cavitation on Model Counterrotating Propellers	Figure 4 - Open-Water Characteristics of Model Counterrotating	
rotating Propellers	_	7
Figure 6 - Cavitation Characteristic Curves of Forward Model Counterrotating Propeller 3808		
Counterrotating Propeller 3808	•	8
Figure 7 - Cavitation Characteristic Curves of After Model Counterrotating Propeller 3809		-0.
rotating Propeller 3809		.9
Propeller 3808		11
Propeller 3808	Figure 8 - Sketches of Cavitation on Forward Model Counterrotating	
		13
Propeller 3809	Figure 9 - Sketches of Cavitation on After Model Counterrotating Propeller 3809	9041

NOTATION

ם	Diameter of propeller
D _F	Diameter of forward propeller
e	Efficiency, $\frac{(T_F + T_A) V_a}{2\pi (Q_F + Q_A) n}$
g	Acceleration due to gravity
H	Absolute static pressure at shaft centerline minus the vapor pressure
J	Speed coefficient $\frac{v_a}{nD_F}$
K _{tA}	Thrust coefficient of after propeller, $\frac{T_A}{\rho n^2 D_F^4}$
K _{tF}	Thrust coefficient of forward propeller , $\frac{T_A}{\rho n^{\frac{2n}{n}}}$
K _{tT}	Total thrust coefficient, $\frac{T_F + T_A}{\rho n^2 D_F^4}$
K _Q A	Torque coefficient of after propeller, $\rho_{n^2} \frac{Q_A}{\rho_{n^2}}$
K _{qF}	Torque coefficient of forward propeller, $\frac{Q_{\overline{z}}}{\rho n^2 D_{\overline{z}}^5}$
K _{qT}	Total torque coefficient, $\rho_{n^2 D_F^5}$
n	Revolutions per unit time
$Q_{\!\mathbf{A}}$	Torque on after propeller
$\mathbf{q}_{\mathbf{F}}^{\mathbf{r}}$	Torque on forward propeller
r	Radial coordinate of propeller
R	Propeller radius
\mathbf{T}_{Δ}	Thrust on after propeller

T _F	Thrust on forward propeller
v	Tunnel reference velocity
v _{a.}	Speed of advance
w	Effective wake fraction, 1 - va
P	Density of water
σ	Cavitation index, $\frac{2gH}{v^2}$
	V _a

ABSTRACT

A pair of counterrotating propellers, designed for the Escort Research Vessel, were tested in the TMB variable pressure water tunnel. Cavitation characteristics of the pair operating in a wake are presented. Cavitation inception curves, open-water characteristics and sketches of the cavitation are included.

INTRODUCTION

As part of a continuing research program a set of counterrotating propellers, designed for the Escort Research Vessel, were built and tested in open water and in the 24-inch variable pressure water tunnel at the David Taylor Model Basin.* The forward propeller was designated TMB 3808 and the after propeller was designated TMB 3809. The drawings and design characteristics of these propellers are shown in Figures 1 and 2.

PROCEDURE

Open-water tests were conducted in the TMB deep-water basin. The propellers were mounted on concentric shafts, and the thrust and torque were measured on each shaft using counterrotating transmission dynamometers. The tests were run from 7.0 to 10.0 rps over a speed range of 3.0 to 12.1 fps, which resulted in Reynolds numbers from 319×10^5 to 6.4×10^5 .

Cavitation tests of the modal counterrotating propellers were conducted in the 24-inch water tunnel equipped with a wake producer. The forward propeller was mounted on the upstream shaft and the thrust, torque, and rpm were measured on the 4-horsepower dynamometer. The after propeller was mounted on the downstream shaft and the thrust, torque, and rpm were measured on the 10-horsepower dynamometer.

^{*} BuShips 1tr AG/S44(644) Ser 644-342 of 12 June 1959 to DTMB.

The wake producer was mounted on the upstream shaft housing, and the radial distribution of the wake was measured with a pitot tube. The wake producer was adjusted until a radial distribution of the wake similar to that of the Escort Research Vessel model was obtained. A comparison of the simulated tunnel wake with the model wake is shown in Figure 3.

The tunnel reference velocity V was measured with a pitot tube located 10 inches from the shaft centerline in the plane of the forward propeller. Pitot tube calibration tests were run, at atmospheric pressure, in which the speed of advance V_a of the propellers was established on the basis of K_{tT} identity with the open-water tests. The total thrust produced by both propellers at equal rpm determined K_{tT} . The reference velocity is related to the speed of advance by the expression $V = \frac{V_a}{1-w}$. The speed of advance was used for all computations.

The cavitation inception tests were conducted over a range of speed coefficients J from 0.90 to 1.44, obtained by varying the rpm from 695 to 1008 at speeds of advance of 12 and 14 fps. The Reynolds numbers of these tests varied from 7.7×10^5 to 9.6×10^5 . At each speed coefficient the cavitation index σ was varied by changing the tunnel pressure. Starting in a noncavitating condition, the tunnel pressure was reduced until cavitation appeared or the cavitation pattern changed. For each speed coefficient, at various cavitation indices, the thrust, torque, and pressure were recorded and sketches of the location of face, back, and tip-vortex cavitation made.

RESULTS

The open-water characteristic curves of model counterrotating propellers 3808 and 3809 are presented in Figure 4, and the inception curves of visible cavitation are shown in Figure 5. The curves in Figure 5 represent the limiting value of cavitation index for inception of the type of cavitation present. Below the curves the intensity of cavitation increases as the cavitation index decreases. At a given speed coefficient and cavitation index, the type of cavitation present may be determined from the curves above this point on the chart.

The thrust and torque coefficients were calculated and plotted against cavitation index, for constant speed coefficients, in Figures 6 and 7. Sketches of visual observations of the cavitation present, at selected values of cavitation index, for the speed coefficients tested are shown in Figures 8 and 9.

DIAMETER10.000 Ins.	PITCH (AT 0.7R)15.205 Ins.	• • • • • • • • • •		DESIGNED BY BUSHIPS
NUMBER OF BLADES	RATIO 0.594	MR 0.317	BTF 0.044	P/D (AT 0.7R)

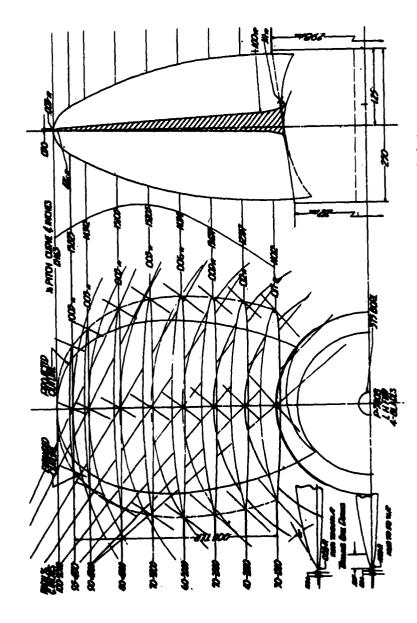


Figure 1 - Drawing of Model Propeller 3808

Figure 2 - Drawing of Model Propeller 3809

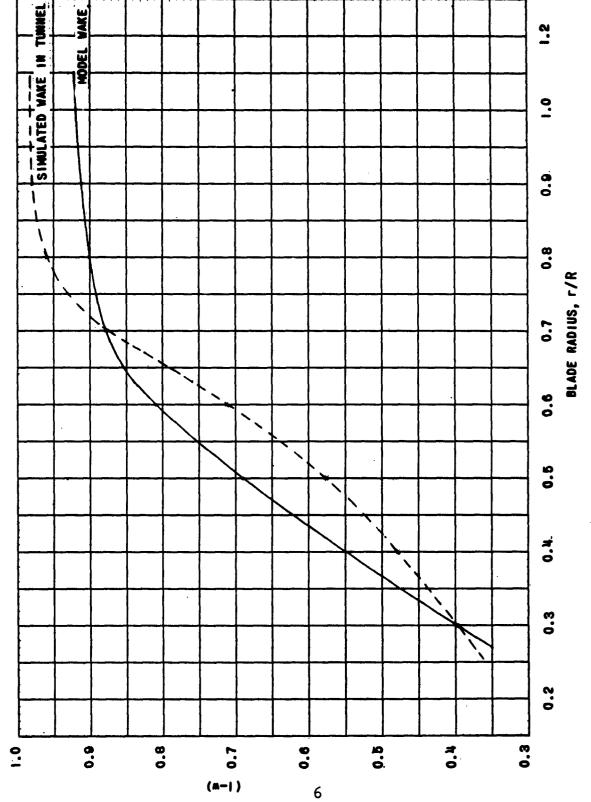


Figure 3 - Comparison of Simulated Tunnel Wake with Escort Research Vessel Model Wake

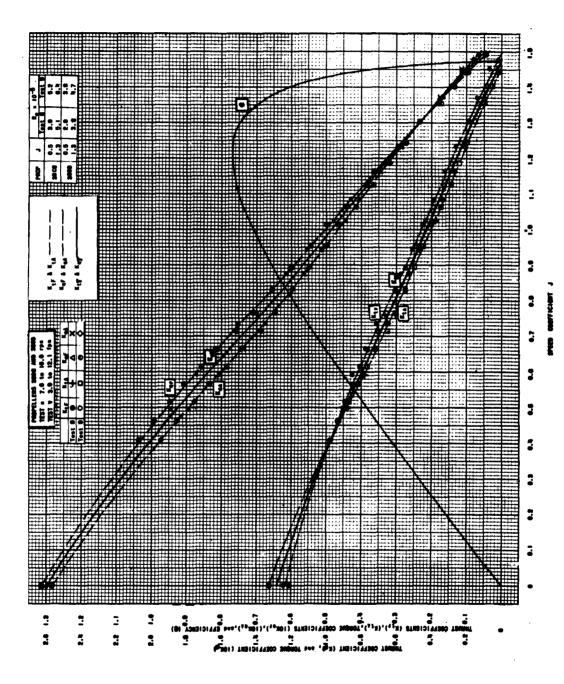


Figure † - Open Water Characteristics of Model Counterrotating Propellers

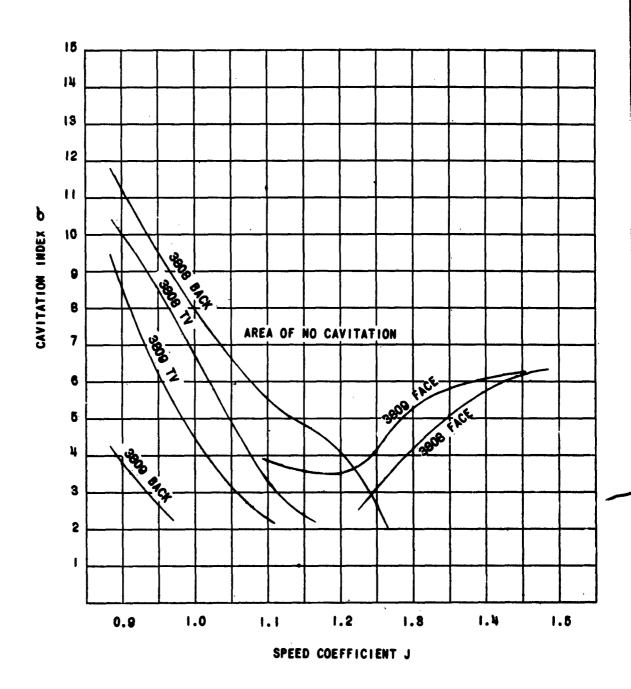


Figure 5 - Inception Curves of Visible Cavitation on Model Counterrotating Propellers

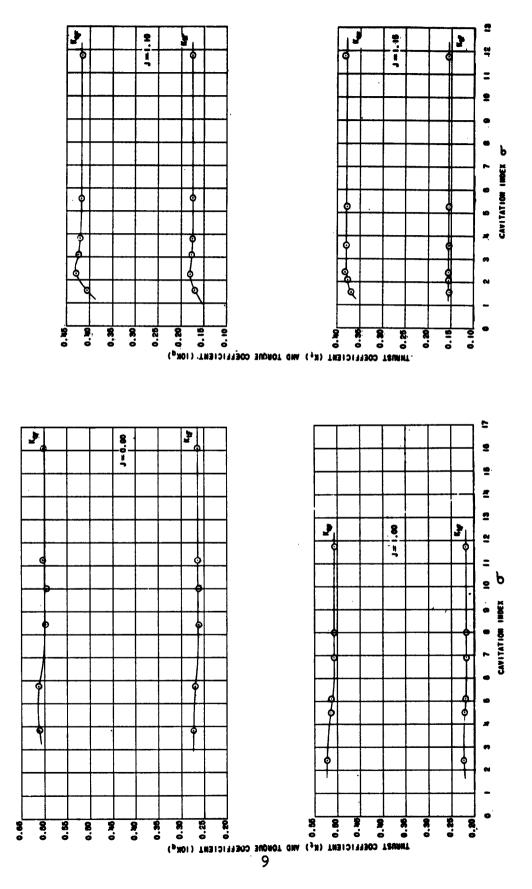


Figure 6a - Cavitation Characteristic Curves of Forward Model Counterrotating Propeller 3808

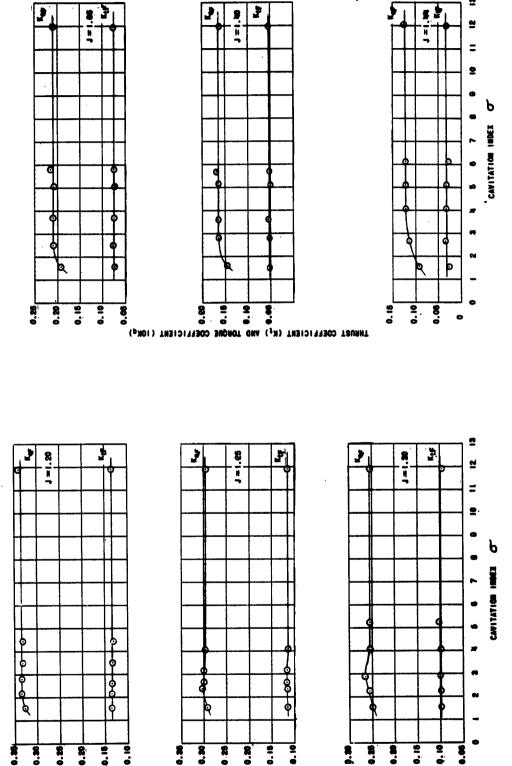


Figure 6b - Cavitation Characteristic Curves of Forward Model Counterrotating Propeller 3808

COEFFICIENT (Kg)

(, 2011) THEIDITION COUNTY STATE (10Kg)

9.0 8 9.18 8

8.0

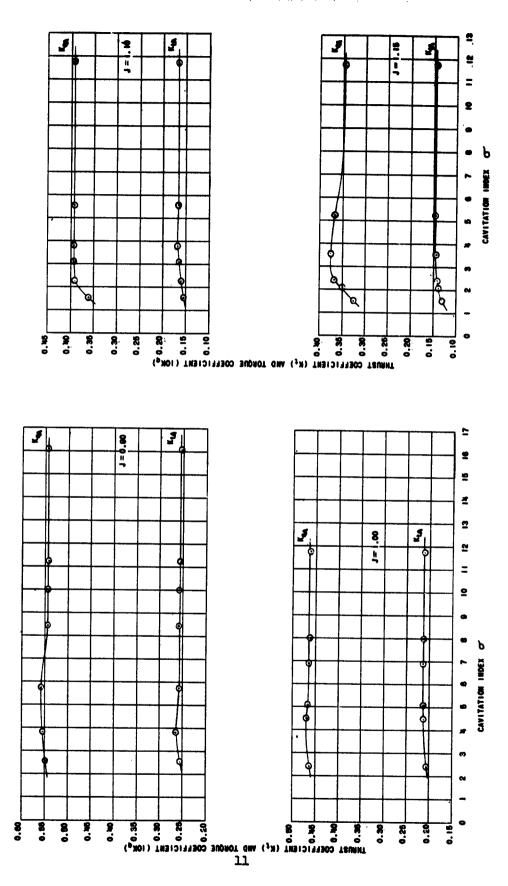
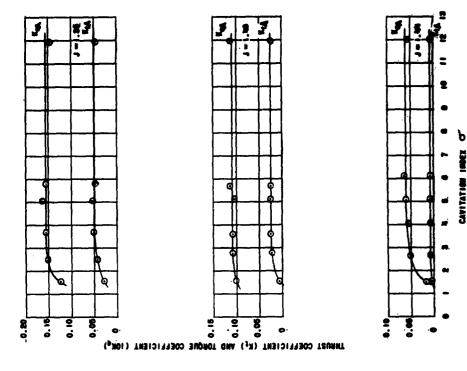


Figure 7a - Cavitation Characteristic Curves of After Model Counterrotating Propeller 3809



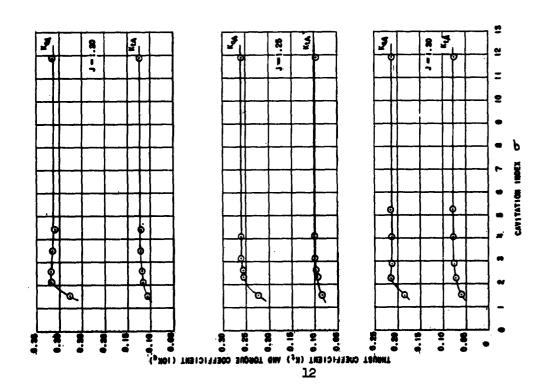


Figure 7b - Cavitation Characteristic Curves of After Model Counterrotating Propeller 3809

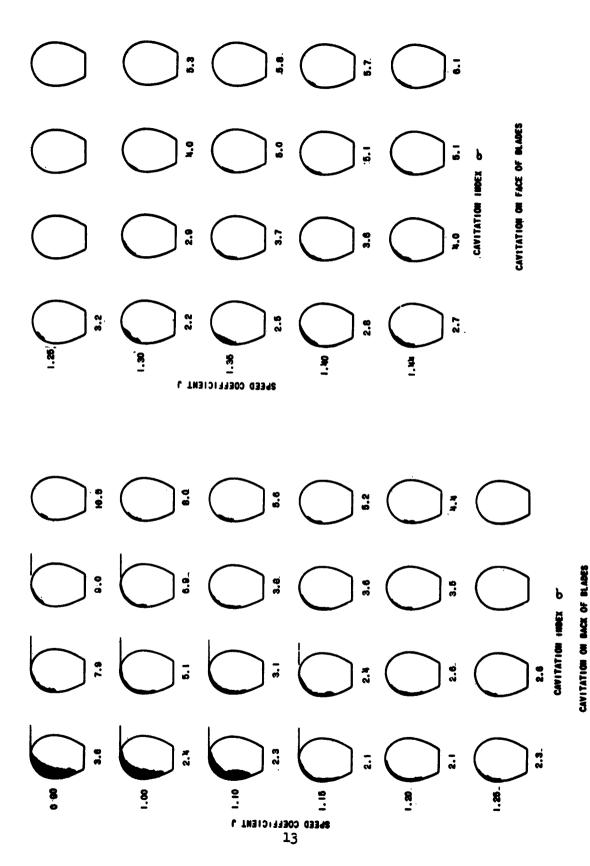


Figure 8 - Sketches of Cavitation on Forward Model Counterrotating Propeller 3808

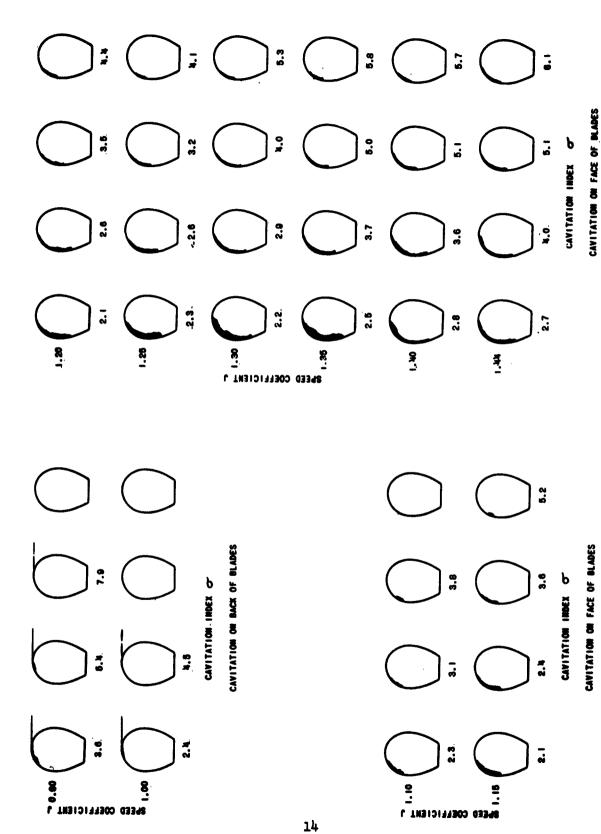


Figure 9 - Sketches of Cavitation on After Model Counterrotating Propeller 3809

INITIAL DISTRIBUTION

Copies

10 CHBUSHIPS

- 1 Lab Mgt Div (Code 320)
- 3 Tech Library (Code 210L)
- 1 Ship Silencing (Code 345)
- 1 Prelim Des (Code 420)
- 1 Mach Sci & Res (Code 436)
- 2 Prop Shafting and Brng (Code 644)
- 1 Hull Des (Code 440)

10 ASTIA

1. Communicating propellers of the communication of	1. Commenceating propel- lars—Cavinates—Test results 2. Propellers—Testing 3. Propellers—Testing 1. Propellers madels— 1. Prop. James G. 1. Frott, James G. 11. S-PUIS GR G.
Devid Toylor Model Besta. Report 1731. CAVITATION TESTS OF ESCUET RESERANCH VESSEL. COUNTERPOTATING PROFELLERS SEE AND SEE IN SHULATED WARE, by James G. Pool. Mar 1862. iv, 15p. illus., graphs. A pair of conterrotating propellers, designed for the Econt Research Vessel, were tested in the 7162 54-in. variable- pressure where tested. Cavitation charochesings of the pair operating in a waln are presented. Cavitation isospition curves, operating in a waln are presented. Cavitation isospition curves, operating in a waln are presented. Cavitation isospition curves, included.	Devid Toylor Model Besin. Report 1731. CAVITATION TESTS OF ESCONT RESEARCH VESSEL. COUNTERPORTING PROPELLERS. Seets AND SEG. IN SECULATED WARE, by James G. Peck. Mar 1982. Fr. 18p. illes., graphs. A pair of conservatating propellers, designed for the Escort Research Vessel, were seeted in the THE 24-in. variable- pressure water times!. Cavitation characteristics of the pair operating in a wale are precessed. Cavitation sorgical curves, operating in a wale are precessed. Cavitation incogition curves, operating characteristics, and shetches of the cavitation are included.
1. Comtestohting propelbers-Cavitation-Test 2. Fropelleter-Testing 3. Propellet models-Model Trift 2506-2509 1. Fool, James G. II. S-FOIS 02 04	1. Consterrotating propoluters—Cavitation—Test 2. Propoliers—Tweting 3. Propoliers models—Model TMB 2806—2809 1. Prot, James G. 11. S-FUIS 08 06
Shrid Toyler thatel Basin. Bayert 1731. CAVEATEM TESTS OF ESCORT RESEABCE VESSEL. COUNTEREMOTATING FROUTLIERS SEES AND SEE IN SMALLATED WAKE, by James G. Pool. Mr. 1882. iv, 15p. Heart Sarphs. A pair of contemotating propellers, designed for the Escort Benesies Vessel, were bessel in the TMS 54-th. veriable- presenter water tennel. Cavitation chemoteristics of the pair open-ender chemoteristics, and shoothes of the cavitation erres- included.	Devid Toylor Madel Basin. Report 1731. CAVITATION TESTS OF ESCORT RESEARCH VESSEL. COUNTERMOTATING PROPELLIZES 8500 AND 8500 IN MEDILATION WARE, by James G. Peol. Mer 1863. iv, 15p. Silman, graphs. A pair of conservateing propellers, designed for the Econt Become what tenned, were besided in the TMS 84-in. variable- property water tenned. Cavitation characteristics of the pair opposite what tenned are proposited. Cavitation incoption curve, opposite characteristics, and checkes of the cavitation are included.